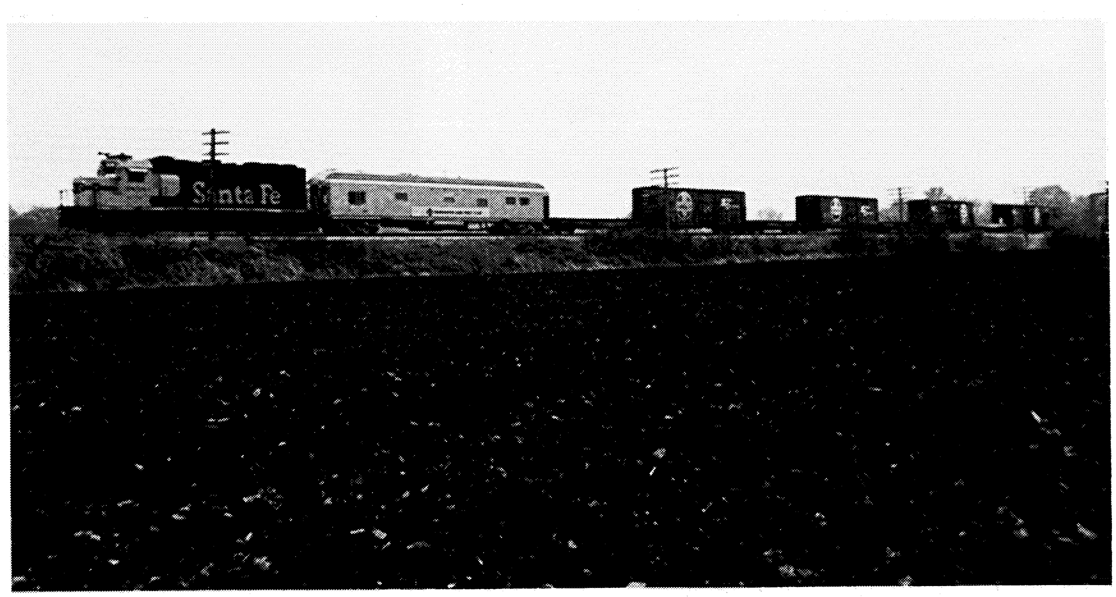
Train Analysis

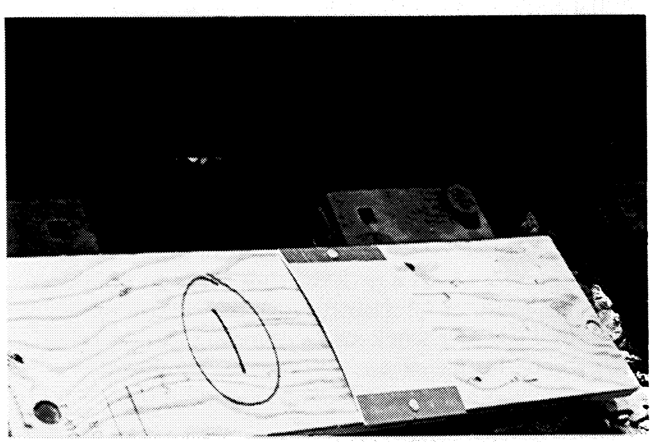
The U.S. railroads have an annual operating budget on the order of $25 billion, a significant portion of it expended on items related to the "running resistance" of trains, or the combined resistance induced by aerodynamic drag and mechanical friction. Overcoming running resistance involves fuel costs amounting to about 16 percent of the operating budget and maintenance/replacement costs for wheels and rails are of similar magnitude.

To decrease running resistance, it is first necessary to quantify it by full-scale train testing, then separate it into its two components—aerodynamic drag and rolling resistance—in order to develop a thorough understanding of total running resistance toward designing more fuel efficient locomotives, cars and components. Such information is essential to an economic analysis that must be conducted to determine the viability of proposed design changes. But information on running resistance is hard to come by; existing methods are felt to be insufficiently accurate. Seeking a better approach, one railroad—The Atchison, Topeka and Santa Fe Railway Company (AT&SF), Topeka, Kansas—is looking into the potential of an aerospace-originated technique for obtaining improved understanding of the characteristics of train running resistance.

AT&SF, primarily a freight mover operating on a 12,500-mile track system, owns approximately 75,000 freight cars and 2,000 diesel electric locomotives. The company uses more than 400 million gallons of fuel a year at a cost of about one dollar per gallon, so even a small percentage reduction would mean significant savings. Over the past several years, AT&SF has undertaken many fuel conservation measures, among them reduced train speed, train handling improvements, equipment design and improved track maintenance standards. The company has also sponsored aerodynamic computer modeling of trains and small-scale wind tunnel tests.



Looking for ways to expand its cost-cutting program, AT&SF became interested in the NASA-developed Coast-Down Technique, which combines the aerospace technology of flight vehicle trajectory analysis with the use of a modern high-speed computer. This technique offers reduced complexity in full-scale testing of rolling stock and promises accurate analysis of a variety of engineering considerations—such as locomotive, car and track design—and operating conditions—such as speed and train configuration. AT&SF entered into a joint agreement with NASA wherein the railroad provided the track, trains, crews and railway survey measurements, while Jet Propulsion Laboratory (JPL) demonstrated the applicability of the Coast-Down Technique. Funding for JPL's effort was provided by NASA's Technology Utilization Office.



The demonstration was conducted over a five-mile segment of straight and near-level track near Pomona, Kansas; a portion of the test area is shown at upper left, opposite page. Several different train configurations were tested, including a base train (middle photo, opposite page); a high-drag train composed of alternating boxcars and flatcars (lower photo, opposite page); a heavily loaded train; two short trains of different load weights; and the locomotive alone. To get the "distance history" of a coasting train, JPL researchers measured distance/time by using a system of reflective targets mounted on the ties every 1,200 feet; one is shown at left. A sensor near the rear step of the locomotive (bottom left) noted the time of passage over each target and reported the information to a computer (bottom right) located inside the test car. Relative wind was recorded by equipment on the test car and absolute wind was determined by an anemometer at wayside.

Distance history data for each of 32 test runs was converted to an accurate "speed history." Test data was computer-processed to obtain total running resistance for each of the various train configurations; running resistance was subsequently separated into the aerodynamic drag and rolling resistance components. JPL analysts reported that the Coast-Down Technique is a practical method of determining the characteristics of running resistance to an accuracy of about one percent, due in part to the absence of data-degrading instrumentation noise encountered in other methods. The field tests were carried out in 1983 and, after several months of data reduction and analysis, JPL submitted its final report to AT&SF last year for further evaluation by the railroad company.